Acuity Technologies

SRI-500
User's Manual

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1. Overview

The SRI-500 Scanning Rangefinding Imager consists of a pulse laser rangefinder, a turret mounted scanning mirror, and a processor with Ethernet for SRI to client communications. The SRI-500 operates by measuring the time difference between a transmitted laser pulse and a received laser pulse and deflecting a high-speed mirror in azimuth and elevation to scan a field up to 130 by 600 degrees.

1.1 Scanning Operation

The SRI-500 acts as a scan data server for a client machine which communicates through a set of commands transmitted via Ethernet. A *scan* is 1 to 30001 vertical lines of rangefinding data. Each vertical line in a scan consists of 1 to 3001 range measurement points. The SRI-500 acquires and transmits scan data in response to scanning commands transmitted to it from the client. Vertical lines are actually slightly sloped, depending on the horizontal and vertical scan speeds set by the client. The maximum vertical scan rate is 500 lines per second.

Scan data comes from the SRI-500 in a UDP packet defined by ScanDataPacket. Each 3D Range data sample is defined by a 16 bit range value, two 16 bit angular direction values, and 1 byte value for signal strength. This can then be converted to Cartesian coordinates by client side software included with the scanner.

1.2 Use and Maintenance

The SRI-500 is a rugged system designed for use on mobile platforms. However, it should be protected from severe shock and vibration, such as that which might be experienced on a vehicle without suspension or with high engine vibration. In these cases the scanner should be mounted with grommets.

The motors for the turret and scanning mirror are brushless DC motors which will not generally need maintenance over the life of the scanner.

The scanner is filled with dry nitrogen and sealed to prevent condensation and corrosion. Do not open the scanner or break any seals. Doing so will void the warranty and necessitate repair.

The front window is filter glass, and should be kept clean ad free of scratches and dirt.

1.3 Azimuth Motor Path Planning

The turret of the SRI-500 moves through scans at nearly constant speeds. To accomplish this, the SRI-500 performs intelligent path planning which moves the azimuth motor into the correct position and speed for the next scan. For this to operate efficiently, it is recommended that the repeating scan command be used, or that commands be queued so that the next scan may be anticipated by the path planning algorithm. A turret positioning command is also available to preposition the turret for quick scan response.

2. Hardware Power Up

2.1 Power/Signal Connection

The SRI-500 requires 11 to 18 Volts and is designed to draw from an automotive or similar power system. The supply must be capable of up to 50 amps burst (0.1 sec) and 15 amps continuous. 24/28V systems are also available. Wire the power supply to the connector cables and plug in the connector with the power switch off, then turn on the system.

An input trigger signal, logic high, is available on the input connector. External triggering of a pre-loaded scanning instruction sequence allows precise synchronization with external events. If not used, this input should be left unconnected.

On power up the turret will seek center and stop with the optical axis aligned with one edge of the scanner housing. The turret window is not aligned with the optical axis, so the window will be at a 10° angle to the housing.

Connect the SRI-500 ethernet jack to a hub, router, or access point with a CAT-5 Ethernet cable or to a client machine with a crossover cable.

Pin A: Power.
Pin B: Ground.
Pin C: Scan Trigger Input.
Pin D: Scan Trigger Return.
If the Scan Trigger Input is used, this line must be connected to logic ground in the signaling device.

3. Software Installation

3.1 CD Directory Structure

The SRI-500 comes with a disk with the following contents:

\doc	- API and users guide
\bin	- precompiled client for Windows XP
\src	- client source code

3.1.1 Ethernet Connectivity

The SRI-500 is configured with a static IP address of 192.168.0.231. It is recommended that this be left unchanged to avoid difficulty in communicating with the SRI-500. If it is necessary to change the IP address or use DHCP, contact Acuity for assistance.

It is recommended that the scanner be used on a 100 Mb ethernet link with only the SRI-500 and the client machine, since the SRI-500 can use nearly the entire bandwidth of this link. Depending on the scan speeds selected, other systems may also use the link, although it is possible that image data will be lost occasionally. Commands are sent to the scanner via TCP, and image data is returned via UDP, so delivery of the latter is not guaranteed in a network environment.

3.2 Software Installation under XP

The SRI-500 installation program starts automatically from the provided CD. Contents are installed by default into Program Files/SRI500.

3.3 Software Installation under Linux

The sample client program may be compiled and executed under most versions of Linux. A makefile is provided in /src.

4. Programming Interface

4.1 Overview

The Application Programming Interface to the SRI-500 consists of commands that set SRI-500 operation modes and parameters and perform scanning sequences. When a command function is called, parameters are validated and a command packet is sent to the scanner over Ethernet using TCP. Up to 3 commands may be transmitted at once, and will be buffered in the SRI-500 until executed. Each call returns a status value which indicates whether the command was valid and whether it was transmitted and acknowledged successfully.

4.2 Status Return Values

```
enum StatusReturnValues {
        eNoError=0,
        eScannerStateInvalid,
        eScannerNotAvailable,
        eInvalidCountRate,
        eScannerBusy,
        eInvalidAzimuth,
        eInvalidNumberOfLines,
        eInvalidElevationStart,
        eInvalidInvalidElevationResolution,
        eInvalidAzimuthDirection,
        eInvalidNumberOfScans,
        eScanPacketIDDoesNotPackSRIImageID
    };
```

4.3 Communication Link Commands

4.3.1 OpenScanner

`SRI500 *scanner = OpenScanner(int timeout, int scannerIndex=0)`

Returns a handle to the scanner communication data, or an error code if connection with the scanner is unsuccessful.

scannerIndex - For systems with only a single scanner, this parameter should be set to 0.. Additional scanners are referenced by scannerIndex 1,2,3 etc.

timeout - the time in seconds attempt open command before failing.

4.3.2 CloseScanner

`int status = CloseScanner(SRI500 *scanner)`

Frees scanner resources and closes the scanner connection.

scanner – Handle to the scanner instances; as returned by OpenScanner

4.4 Scanning Location and Speed Commands

The speeds of the scans, and the scan start and stop vertical and horizontal locations are based on the internal scanning motor encoder counts. The vertical scan resolution is 8000 counts per 360 degrees of optical scan angle (16000 counts per elevation motor rotation). The horizontal resolution is 16000 counts per 360 degrees of optical scan angle.

4.4.1 azimuthSpeed

int status = azimuthSpeed(SRI500 *_scanner_, int _countsPerSec_)

scanner – Handle to the scanner instances; as returned by OpenScanner
countsPerSec – Default: 8000 counts/sec Range: 1-50,000

Sets the rotation speed of the turret during scans. The turret speed will vary before and after scans as the turret is positioned for the next scan. One revolution of the turret is 16000 counts. The turret will stop after a scan if no further scans are queued.

4.4.2 elevationSpeed

int status = elevationSpeed(SRI500 *_scanner_, double _linesPerSec_)

scanner – Handle to the scanner instance; as returned by OpenScanner
countsPerSec – Default: 500.0 Range: 50.0 – 500.0

Sets the speed of the elevation motor. This can up to one second to settle, so the elevation motor may generally left running at constant speed. The elevation motor does not stop after scans are completed.

The elevation speed in lines per second is converted to elevation motor encoder counts by multiplying by 16000/3, since there are 16000 encoder counts and 3 scans per revolution. This can be used to calculate the range sampling rate from the elevation speed and elevation resolution in encoder counts per sample. The latter is the ***elevationResolution*** parameter in **singleScan** and **repeatingScan.**

The scan speed parameters are not guaranteed to hold exactly during a scan, although they will generally be close unless extreme platform motion occurs during a scan. Actual locations, speeds, and times of each range sample in a scan are reflected in the coordinates and timestamp of each range point.

4.4.3 azimuthPosition

int status = azimuthPosition(SRI500 *_scanner_, int _counts_)

scanner – Handle to the scanner instances; as returned by OpenScanner
counts – Range: -15000 - 15,000

Sets the position of the azimuth motor. The turret will move to the commanded location. If no further commands are queued after this one, the turret will stop at that position. This may be used to position the turret ahead of time, so that the delay between triggering a scan and actual rangefinding is minimal.

4.5 Mode Commands

4.5.1 scanOnCommand

int status = scanOnCommand(SRI500 *_scanner_)

scanner – Handle to the scanner instances; as returned by OpenScanner

Default setting. Configures the SRI-500 to execute scan commands when they are received or when the previous command is completed and another is found in the queue.

4.5.2 scanOnSoftwareTrigger

int status = scanOnSoftwareTrigger (SRI500 *_scanner_)

scanner – Handle to the scanner instances; as returned by OpenScanner

Configures the SRI-500 to hold execution of each subsequent scan command until a Trigger command reaches the head of the command queue. When a scan command reaches the head of the command queue while in this mode the scanner stops the azimuth motor in a position appropriate for initiating the scan. Trigger command must be the next command sent or the SRI-500 will cease executing commands other than the Halt command. A Halt command will remove the pending scan from the queue.

4.5.3 scannerTrigger

int status = scannerTrigger(SRI500 *_scanner_)

scanner – Handle to the scanner instances; as returned by OpenScanner

Initiates execution of a scan command if one is ready to run and the system is in the ScanOnSoftwareTrigger mode. If either of these conditions is not true, the command is disregarded. Some latency will occur after transmission of the trigger command due to azimuth motor startup delay (if the azimuth motor has slowed or reached a stop) and to the delay for the vertical axis motor to reach the scan start position.

4.5.4 scanOnHardwareTrigger

int status = scanOnHardwareTrigger (SRI500 *_scanner_)

scanner – Handle to the scanner instances; as returned by OpenScanner

Configures the SRI-500 to hold execution of each subsequent scan command until the trigger pulse input is high. If the trigger is low when a scan command reaches the head of the command queue while in this mode, the scanner stops the azimuth motor in a position appropriate for initiating the scan and awaits a high level on the trigger line. Some latency will occur after transmission of the trigger signal due to azimuth motor startup delay (if the azimuth motor has slowed or reached a stop) and to the delay for the vertical axis motor to reach the scan start position.

4.5.5 scannerSleep

int status = scannerSleep(SRI500 *_scanner_)

scanner – Handle to the scanner instances; as returned by OpenScanner

Stops both motors. In normal (awake) operation the elevation motor runs at its current speed setting during gaps between commands, while the azimuth motor stops. The elevation motor may be stopped to conserve power and motor bearings during long idle periods. This command does not affect the state of the processor or other electronics in the system. Since the vertical axis motor startup time may be several seconds for higher speeds, the **scannerWake** command should be used prior to the need for scan data.

4.5.6 scannerWake

int status = scannerWake(SRI500 *_scanner_)

scanner – Handle to the scanner instances; as returned by OpenScanner

Starts the vertical axis motor and brings it to the last commanded speed.

4.6 Scan and Turret Motion Commands

Scan commands direct the SRI-500 to take one or more scans each consisting of a sequence of vertical line scans. The elevation motor speed controls the rate of scan line acquisition. The ratio of elevation and azimuth motor speeds, previously specified, controls the slope of the scan lines. The start azimuth and elevation angle, the number of vertical lines to be acquired, the elevation resolution (number of elevation motor encoder counts per range sample), and the scan azimuth direction are specified in each command.

The timing of scan initiation depends on the mode previously set with the Mode command group.

4.6.1 singleScan, repeatingScan

```
int status = singleScan (SRI500 *scanner, int azimuthStart, int azimuthEnd,
      int elevationStart, unsigned pointsPerLine,
      unsigned elevationResolution)
int status = repeatingScan (SRI500 *scanner, int azimuthStart,
      int azimuthEnd, int elevationStart, unsigned pointsPerLine,
      unsigned elevationResolution, unsigned numberOfScans)
```

scanner – Handle to the scanner instances returned by OpenScanner
azimuthStart – Range: -15000 to 15000, or -330 to 330 degrees
azimuthEnd – Range: -15000 to 15000, or -330 to 330 degrees
elevationStart – Range: -1500 to 1500, or -67.5 to 67.5 degrees
pointsPerLine – Range: 1 to 3001, or -67.5 to 67.5 degrees
elevationResolution – Range: 1 to 2000 counts per point
numberOfScans – Range: >=0. A value of 0 will repeat until haltScan() or power down.

The number of vertical lines obtained in the scan is determined by the speeds most recently specified with **elevationSpeed** and **azimuthSpeed.** The ending elevation angle of each scan line is determined by **pointsPerLine** and **elevationResolution.** Any points below -67.5 degrees elevation will not be sampled. Note that the optical angle change between successive points will be twice the motor encoder angle change in elevation due to mirror geometry: specifying a sample every elevation encoder count results in angular separation of the samples of 360/8000 = .045 degrees.

Example

Scan through 135 degrees in azimuth from 90° left of straight ahead to 45° right, and 45° degrees of elevation above horizontal down to 45° below horizontal, acquiring 200 points per vertical scan. The line rate and turret speeds are set up to acquire one vertical line for every 20 encoder counts (0.45 degrees) of turret rotation, or 300 lines in total. Acquire one or four scans. The scan parameters are determined by:

```
int status = elevationSpeed(scanner, 500); //will acquire 500 vertical
     //lines per second in next scan(s).

int status = azimuthSpeed(scanner, 10000); // move turret at 10000
     //encoder counts/second (225 degrees/sec) in next scan(s).
```

```
int azimuthStart = -4000;  // corresponds to 90 degrees left of
       //straight ahead (-16000 to 16000) = (-2pi, 2pi)

int azimuthEnd = 2000; // corresponds to 45 degrees right

unsigned elevationStart = 1000; // corresponds to 45 degrees above
       //horizontal

unsigned pointsPerLine = 200;

unsigned elevationResolution = 10; //  separation of measurement
       //points in vertical scan axis counts: 10 will give 200 points
       //in 2000 elevation encoder counts, or 90 degrees

status = singleScan (scanner, azimuthStart, azimuthEnd,
       elevationStart, pointsPerLine, elevationResolution);
// or
status = repeatingScan (scanner, azimuthStart, numberOfLines,
       elevationStart, pointsPerLine, elevationResolution, 4);
```

The singleScan command will position the turret to a position that will allow it to accelerate to constant speed specified by the starting azimuth location and then accelerate to the current scan speed parameters and initiate a scan.

The repeatingScan command starts in the same way and reverses direction as rapidly as possible between scans. Successive scans in a repeating scan are taken in opposite directions. Time for the repeating scans will include the scan times and turret reversal times.

4.6.2 haltScan

int status = haltScan(SRI500 *_scanner_)

scanner – Handle to the scanner instances; as returned by OpenScanner

Aborts the current scan and ceases data transmission. Stops the azimuth motor. This command is processed asynchronously so that any scan in progress is aborted before completion. Scans queued prior to the Halt Scan command are flushed without execution.

4.7 Scan Data Acquisition and Processing

Data is received from the scanner once per vertical line of range points acquired. The ***nLines*** parameter in **createSRIPacketBuffer** determines the number of vertical lines collected in each packet when **`receiveImagePacket`** is invoked. The packet size is dependent on the number of lines in a packet and the number of range points per line. The number of packets per scan depends on the number of lines in a packet and the number of lines in a scan.. Each packet has a scanId, a packetNumber, and a timestamp. The scanId is the value provided when **`singleScan`** is invoked, or the value provided when **`repeatingScan`** is invoked. The timestamp is a measure of the time the first sample of the packet was taken.

After the scanId is a packet number ID. This starts at 1 with each new scan. Following this is the total number of packets that this image will arrive in, and first/next line of data in the scan. Direct operations on the packets by client code will generally only need to be performed by the functions described below.

4.7.1 createSRIpacketBuffer

`SRIImage *packet = createSRIpacketBuffer (int` ***`nLines`*****`, int`** ***`samplesPerLine`*****`)`**
`returns`

packet - Pointer to initialized structure and allocated space. NULL if allocation was not successful.

```
Struct SRIPacket
{
        short scanId;
        short packetNumber;
        long packetTimeStamp;
        short checksum;
        unsigned char data[k_dataPacketSize];
};
```

Allocates image space and initializes structures for assembly of an image from packets received from the SRI500. In typical usage, a client application might create one of these, execute **`receiveImagePacket`** followed by **`addPacketToImage,`** and then re-use the packet buffer to obtain the next packet.

4.7.2 deleteSRIpacketBuffer

`int status = deleteSRIpacketBuffer(SRIpacket *`*`packet`*`)`
`returns`

`eNoError` or **`eInvalidAlloc`** if not a valid packet pointer.

Frees packet space allocated by **`createSRIpacketBuffer`**

4.7.3 receiveImagePacket

int status = receiveImagePacket(SRI500 ****scanner*, unsigned *timeout*, SRIPacket ****packet***)**

scanner – Handle to the scanner instance; as returned by OpenScanner
timeout – time to wait for a packet in milliseconds
newPacket – target structure for packet data

Acquires packets of data from the scanner. Performs reception of packets and packet integrity checking. Packets may be lost if this is not invoked before operating system buffers fill. The sample code provided illustrates how this client size buffer size can be increased to reduce the risk of packet loss in the event of client data processing delays.

Transmission from the scanner to the client occurs once per vertical line acquired. For minimum latency on the client, create packets with only one line. For lower overhead, create packets with more lines.

Packet reassembly into a full image may be performed in the client with assembleImage. Range and angle are converted into Cartesian coordinates in meters. This should be invoked repeatedly with each packet received until the entire image has been assembled.

4.7.4 createSRIImageBuffer

SRIImage *image = createSRIImageBuffer(int nLines, int samplesPerLine)

nLines – number of lines that will be in the image assembled in this image buffer.
samplesPerLine – number of samples per scan line

returns

image **-** Pointer to initialized structure and allocated space. NULL if allocation was not successful.

Allocates image space and initializes structures for assembly of an image from packets received from the SRI500.

Assembled Image Format - SRIImage

```
Struct SRIImage
{
      int nLines;
      int samplesPerLine;
      long scanTimeStamp; // time of the first packet added to image
      float *x;
      float *y;
      float *z;
      float *reflectance;
      unsigned *time;
};
```

The SRIImage structure matches the data that was specified in the original scan command.

The *scanTimeStamp* is the elapsed time from the start of the scan in microseconds. This elapsed time can be converted to time relative to other scans by adding *scanTimeStamp* to the value. The start of the scan is the time at which the scan command or trigger is detected and execution of the scan begins. The first range measurement is taken after the azimuth motor has reached the commanded starting position and speed.

The structure contains five arrays. The first three of these contain the x,y,z point locations, in meters from the rangefinder at the time the pixel was acquired. The fourth contains the surface reflectances. Reflectance can vary slightly from unit to unit, with temperature and with the cleanliness of the scanner window.

The *time* array is the elapsed time from the start of the scan in microseconds of each sample in the scan. This elapsed time can be converted to time relative to other scans by adding *scanTimeStamp* to the value. The start of the scan is the time at which the scan command or trigger is detected and execution of the scan begins. The first range measurement is taken after the azimuth motor has reached the commanded starting position and speed.

4.7.5 deleteSRIImageBuffer

void deleteSRIImageBuffer(SRIImage *_image_)
returns

eNoError or **eInvalidAlloc** if not a valid image pointer.

image - Pointer returned by **createSRIImageBuffer**

Frees image space allocated by **createSRIImageBuffer**.

4.7.6 addPacketToImage

int status = addPacketToImage(SRI500 *_scanner_, SRIPacket* _packet_**,**
SRIImage * _imageBuffer_)

scanner – Handle to the scanner instances; as returned by OpenScanner
packet – Pointer to the packet received
imageBuffer – `SRIImage` structure allocated by the calling software

returns

ePacketSizeMismatch if *samplesPerLine* of the packet does not match that of the image.

4.8 Demonstration Client Software

The demonstration program SRI500Client.exe which runs under Windows XP is supplied in /bin. This program was compiled with Microsoft Visual C++ 6.0. It demonstrates the SRI500 API and programmable modes. The client demonstration software include routines for converting range, azimuth and elevation counts, and signal strength to corrected range, target reflectance, and Cartesian coordinates with the scanner at the origin.

To check connectivity between the client and SRI-500, start the SRI-500 and wait _ seconds for the power up and turret centering process to complete. Then start the client demonstration program.

SAFETY NOTE: The turret will move rapidly and laser light is emitted from the window during demonstration program operation. Although the SRI-500 laser output is safe in normal operation, care should be taken to avoid circumstances that might result in injury or damage. Ensure that the turret is free to move and that the system is firmly seated on a level surface. Do not look into the window using magnifying optics.

Under control of the demonstration software the SRI-500 will take a scan from -360 to 360 degrees, or 2 revolutions, convert the received data, and display the results. The range image is shown above the reflectance image. Light areas in the range image are nearby, while darker areas are more distant. In the reflectance image, return signal strength is compensated for distance to obtain the actual reflectance of objects.

4.9 SRI-500 data sheet, following pages.

SRI-500

Scanning Laser Rangefinder with Inertial Image Stabilization

The SRI-500 Laser Rangefinder is an omnidirectional scanning range image acquisition system for obtaining range images from stationary or mobile platforms at distances up to 500 feet and 800,000 points per second. Scanning is a combination of fast vertical scans at 500 lines/s combined with an azimuth sweep rate of up to 1000°/s.

3D point datasets are acquired by setting vertical and horizontal sweep rates, and commanding acquisition of a sequence of vertical scan lines through a specified elevation and azimuth range. The SRI-500 can be programmed to auto-cycle through an azimuth region repeatedly, automatically reversing direction.

The SRI-500 communicates with a host via a TCP-IP connection. The host may issue Laser Enable, Motor Speed, and Take Scan commands through software based on sample source code provided with the scanner. Each scan consists of a sequence of nearly vertical scan lines taken between start and stop platform azimuth and elevation angles. Elevation coverage may be programmed from +65° to -65°and azimuth from +300° to -300°. The scan head is capable of two complete rotations in azimuth, lock to lock, to maximize programming flexibility.

Optional Inertial Measurement Unit

In mobile applications, the optional internal inertial measurement unit captures platform vibration and rotation at 200 Hz and is used to correct the 3D coordinates of each sample point to create a stabilized world referenced dataset. Data for each scan is corrected to the initial platform inertial orientation during acquisition. Platform orientation and velocity changes between and during scans are reported with each scan, so multiple scans may be registered in a world map and vehicle motion may be derived. In static applications the internal IMU may be used to register earth vertical which provides absolute orientation information for structures captured.

Specifications

Scan Angles
- Azimuth: ± 360°
- Elevation: ± 65°

Scan Speed:
- Vertical: 500 lines/s max
- Horizontal: 1000°/s max

Measurement Acquisition Rate: Approx. 800,000 points/sec peak during vertical scan

Range Accuracy, 1σ	1.5 inches
Maximum Range, 85% Reflectance Lambertian Surface	500 feet
Minimum Range	3 feet
Laser Wavelength	905 nm
Eye Safety	Eye safe
Average Laser Power	< 1 mW
Laser Interlock	Vertical scan mirror encoder
Laser Spot Divergence	2 millirad H × 0.5 millirad V
Optical Aperture	2” × 8.5”
Scan Motors	Long life brushless DC
Azimuth Accuracy, Platform Relative	1.5 arc-min
Elevation Accuracy, Platform Relative	1 arc-min

Range Gating
- Minimum and maximum range limits in increments of 12.5 feet from 3 to 500 feet.

Weight:	33 lb.
Power:	50 W, 12-28 VDC

Environmental

Enclosure	IP65 / NEMA-4 waterproof
Operating Temperature	-20 to 70 C shade, -20 to 50 C direct sun
Storage Temperature	-40 to 85 C
Shock and Vibration	5G operating, 10G survival
Connectors	Waterproof, UV resistant power and ethernet
Optical Head	Sealed, dry nitrogen filled

Inertial Measurement Unit Option

6-Axis quartz accelerometer/gyro AHRS system

Image Stabilization
- Azimuth drift 0.05°/sec
- Pitch/roll drift 0.02°/sec
- Pitch/Roll Earth Vertical Attitude Accuracy
  - Stationary 0.1°
  - Maneuvering Vehicle 0.5° typical

Output Data

Physical Data Interface:	100 Base-T Ethernet
Application data rate:	25.6 Mbit/s at max scan rate
Data Output:	Streaming scan packet data
Latency:	100 milliseconds maximum

Scan Packet
- Packet Header
  - Timestamp
  - Inertial Velocity Change from Previous Scan End
  - Inertial Azimuth Change From Previous Scan End
- Point Sample Data
  - Range: 0.1 inch resolution, 0 to 6500 inches
  - Azimuth: 0.02^{o} resolution
  - Elevation: 0.01^{o} resolution
  - Relative Return Signal Strength
  - Time From Previous Sample
- Packet Trailer
  - Timestamp
  - Inertial Velocity Change from Scan Start
  - Inertial Azimuth Change From Scan Start

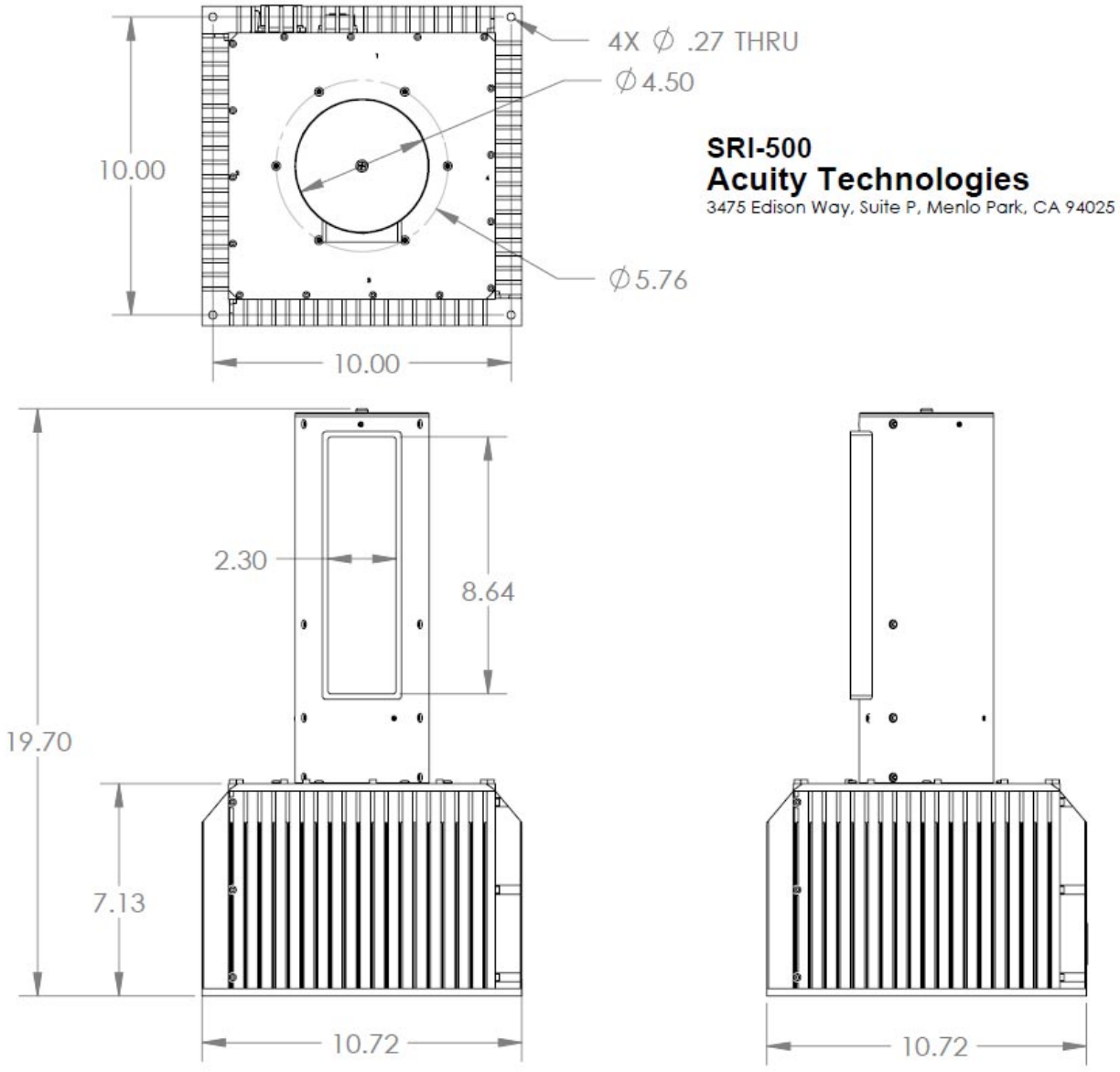
Reference Coordinate Systems for Output Data

With Inertial Option	Elevation angle relative to Earth Vertical Azimuth relative to platform orientation at start of scan OR relative to instantaneous platform orientation
Without Inertial Option	Elevation and azimuth relative to instantaneous platform orientation

Command Set

Set Azimuth Scan Speed
Set Elevation Scan Speed
Take Single Scan
Take Repeating Scans (Auto-reverse in azimuth)
Laser Enable
Halt Scan

Maximum Scan Duration: 10,000 vertical lines (20 seconds), up to 600^{o} azimuth
Minimum Scan: 1 vertical line (2 milliseconds)



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